This invention relates to an improved system and process for controlling the hot water process for the treatment of tar sands. Tar sands are primarily composed of a fine quartz sand having a particle size greater than that passing a 325 mesh screen. The quartz sand is impregnated with a bitumen in quantities of from 5 to 21 weight percent of the total composition. More typically the bitumen content is from 8 to 15 percent. This bitumen is quite viscous and contains typically 4.5 percent sulfur and 38 percent aromatics. Its specific gravity at 60°F. ranges typically from about 1.00 to about 1.06. In addition to the bitumen and quartz sand, the tar sands contain clay and silt in quantities of from 1 to 50 weight percent of the total composition. Silt is defined as material which will pass a 325 mesh screen but which is larger than 2 microns. Clay is material smaller than 2 microns including some siliceous material of that size.

Several basic extraction methods have been known for many years for the separation of bitumen from the sands. In the so-called "cold water" method, the separation is accomplished by mixing the sands with a solvent capable of dissolving the bitumen constituent. The mixture is then introduced into a large volume of water, water with a surface agent added, or a solution of a neutral salt in water. The combined mass is then subjected to a pressure or gravity separation.

In the hot water method, the bituminous sands are jetted with steam and mulled with a minor amount of hot water at temperatures in the range of 140° to 210°F. The resulting pulp is dropped into a stream of circulating hot water and carried to a separation cell maintained at a temperature of about 150° to 200°F. In the separation cell, sand settles to the bottom as

tailings and bitumen rises to the top in the form of an oil froth. An aqueous middlings layer containing some mineral and bitumen is formed between these layers. A scavenger step may be conducted on the middlings layer from the primary separation step to recover additiona amounts of bitumen therefrom. This step usually comprises aerating the middlings as taught by K. A. Clark, "The Hot Water Washing Method", Canadian Oil and Gas Industries 3, 46 (1950). These froths can be combined, diluted with naphtha and centrifuged to remove more water and residual mineral. The naphtha is then distilled off and the bitumen is coked to a high quality crude suitable for further processing.

Floyd et al., Canadian Patent 841,581 issued May 12, 1970, teach a hot water process in which water incorporated with the bituminous sands for discharge into the separation cell and the rate of passage of the middlings from the separation cell to the scavenger step are both regulated in order to maintain the density of the middlings layer within the range of 1.03 to 1.50 and/or the viscosity of the middlings within the range of 0.5 to 10 centipoises. Canadian Patent Application Serial No. 024,558, Graybill et al., relates to a means for controlling the process of Floyd et al. Floyd et al. point out that bitumen froth recovery is affected by control of the viscosity of the middlings within a specified range. Graybill et al. show that the viscosity of the middlings should be maintained within the range of about 0.4 to about 5.7 centipoises measured at 190°F. As Floyd et al. point out, the viscosity is relatable to middlings clay

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content which can be maintained by regulating the amount of water incorporated with the bituminous sands in the initial pulp forming stage and the rate of passage of the middlings from the separation cell to the scavenger step. Graybill et al. show that middlings clay content is relatable to the "settled density" of the middlings where "settled density" is defined as measured density determined when mineral material which will not pass a 325 mesh screen has substantially settled out from the middlings sample. The viscosity of the middlings in the separation cell can be maintained within the desired range of about 0.4 to 5.7 centipoise by regulating the clay content of the middlings by maintaining the settled density of the middlings within the range of about 1.03 to 1.09 g./ml.

The Graybill et al. 024,558, invention relates to a system and process for measuring the settled density of the separation cell middlings and for regulating water feed rates to the process in response to these measurements. The process comprises introducing a portion of the middlings from the hot water process separation cell into a sampling system. In the sampling system entrained sand is substantially removed by settling from the portion of the sample which was to be analyzed. The density of the sample is measured as the sample settles and the water incorporated into the tar sands and the stream to the scavenger zone from the separation cell are regulated in response to this measurement so as to maintain the viscosity of the middlings in the separation cell within the range of 0.4 and 5.7 centipoises or preferably about 1 to 2 centipoises. In operation a sample of

middlings is withdrawn from the separation cell and sent to a sample cell where the sample is settled and density measured by means of a densitometer. The densitometer controls a variable speed pump on the middlings withdrawal line so that if the settled density of the sample registers above the range 1.03 to 1.09 the flow through the pump is increased. Increased flow of middlings fom the separation cell lowers the interface level between the middlings and froth in the separation cell activating a float which opens a valve controlling fresh water feed to the separation cell thus increasing the proportion of fresh water to middlings recycle water in the diluted tar sands pulp entering the cell. An increase in the proportion of fresh water lowers the middling density back to within the range 1.03 to 1.09. If the settled density of the middlings sample registers below the range 1.03 to 1.09 the flow through the middlings discharge pump decreases, the interface level in the cell rises activating the float which closes the valve controlling fresh water feed thereby decreasing the proportion of fresh water to middlings recycle water in the feed thereby raising middlings density in the separation cell back into the desired range.

The present invention relates to an improvement to both the system and process for conducting the hot water process as proposed by Graybill et al. 024,558. In the present invention a bubble tube-differential pressure sensing system is used to measure the change in separation cell froth-middlings interface level instead of the float valve used by Graybill et al., 024,558. This bubble tube-differential pressure sensing system is particularly advantageous over use of a float valve or any mechanical device such as a displacer for measuring the change in

interface level in a hot water process separation cell. The bubble tube-differential pressure sensing system is unaffected by the particular nature of the system in which the particular level sensing device must operate. The bubble tube-differential pressure sensing system does not become fouled by the bitumen froth as do mechanical devices and is therefore significantly more reliable than such devices. Bitumen in the system can adhere to mechanical devices and cause drag in response to level changes while air bubbles in the froth can collect on the devices increasing buoyancy and causing inaccurate level change responses. None of these problems effects the bubble tube-differential sensing device of the present invention and for these reasons the present invention reflects a significant improvement to the process and system of Graybill et al., 024,558.

The system of the present invention is described as an improvement to the system of Graybill et al., 024,558, wherein that system comprises a conditioning drum; a separation cell; a first line for supplying tar sands pulp from the conditioning drum to the separation cell; a second line for introducing hot water into tar sands pulp in the first line; a third line for withdrawing a bitumen froth product from the cell; a fourth line for withdrawing a sand tailings layer from the cell; a fifth line for withdrawing a middlings portion from the cell; a sixth line for recycling a middlings portion from the cell to be mixed with the tar sand pulp prior to discharge into the cell; and which further comprises:

(a) a sampling device for withdrawing a sample of middlings from the cell;

(b) a density sensing device connected to the sampling device for measuring the settled density of the sample;

(c) regulating means controllably attached to the fifth line, and responsively connected to the density sensing device to control the middlings portion withdrawn via the fifth line;

(d) regulating means operating in response to the middlings withdrawn in the fifth line and connected to the second line to control the hot water introduced to the bituminous tar sands pulp via the second line; and

(e) regulating means operating in response to the hot water incorporated in the second line and connected to the sixth line to control the middlings portion recycled to the bituminous tar sands pulp via the sixth line.

The improvement is describable as the above system wherein the regulating means (d) operating in response to the middlings withdrawn in the fifth line and connected to the second line to control the hot water introduced to the bituminous tar sands pulp via the second line comprises: a bubble tube-differential pressure cell positioned to operate in response to the middlings withdrawn in the fifth line and connected to the second line to control the hot water introduced to the bituminous tar sands pulp via the second line.

The process of the present invention is described as an improvement to the process of Graybill et al., 024,558, where the Graybill process is a hot water process for treating

bituminous tar sands comprising: forming a pulp of bituminous tar sands with a minor amount of water in a pulping zone; removing pulp therefrom and mixing the same with hot water and a hereinafter specified recycle stream in a dilution zone; passing the mixture into a separation zone; settling the mixture in the separation zone to form an upper bitumen layer, a middlings layer comprising water, clay and bitumen, and a sand tailings layer; removing a first stream of middlings layer from the separation zone and passing it to the dilution zone as the aforesaid recycle stream; passing a second stream of middlings layer to a scavenger zone and therein recovering an additional amount of bitumen froth; and regulating the rate of passage of said second stream to the scavenger zone so as to regulate and maintain the viscosity of said middlings layer within the range of about 0.4 to 5.7 centipoises; the process further comprising:

(a) regulating the rate of passage of the second stream to the scavenger zone thereby varying the interface level between said upper bitumen froth layer and the middlings layer in said separation cell;

(b) varying the amount of hot water mixed in the dilution zone in response to the variation of the interface level; and

(c) varying the rate of passage of the first stream of middlings to the dilution zone in response to the variation in the amount of hot water in the dilution zone.

The improvement is describable as the above process wherein Step (b) comprises varying the amount of hot water mixed in the dilution zone in response to pressure variance

required to inject a gas into the middlings below the interface which pressure varies in relation to the variation of the interface level.

The process of this invention can be best described with reference to the drawing which is a schematic flow sheet of a hot water process utilizing the improved middlings control system of the present invention. The process shown in the drawing is a preferred embodiment of the present invention.

In the figure, bituminous tar sands are fed into the system through line 1 where they first pass to a conditioning drum or muller 3. Water and steam are introduced from 2 and mixed with the sands. The total water so introduced is a minor amount based on the weight of the tar sands processed and generally is in the range of 10 to 45 percent by weight of the mulled mixture. Enough steam is introduced to raise the temperature in the conditioning drum to within the range of 130° to 210°F. and preferably to above 170°F.

An alkali metal-containing alkaline reagent can also be added to the conditioning drum usually in amount of from 0.1 to 3.0 pounds per ton of tar sand. The amount of such alkaline reagent preferably is regulated to maintain the pH of the middlings layer in the separator zone within the range of 7.5 to 9.0. Best results seem to be obtained at a pH value of 8.0 to 8.5. The amount of the alkaline reagent that needs to be added to maintain a pH value in the range of 7.5 to 9.0 may vary from time to time as the composition of the tar sands as obtained from the mine site varies. The best alkaline reagents to use for this

purpose are caustic soda, sodium carbonate or sodium silicate, although any of the other alkali metal-containing alkaline reagents can be used if desired.

Mulling of the tar sands produces a pulp which then passes from the conditioning drum as indicated by line 4 to a screen indicated at 5. The purpose of screen 5 is to remove from the tar sand pulp any debris, rocks or oversized lumps as indicated generally at 6. The pulp then passes from screen 5 as indicated by 7 to a sump 8 where it is diluted with additional water from 9 and a middlings recycle stream 10. This recycle stream serves to provide sufficient liquid to make the tar sands pulp pumpable so that it can be transferred to the separation zone.

Modifications that may be made in the process as above described include sending a minor portion of the middlings recycle stream from line 10 through a suitable line (not shown) to the conditioning drum to supply all or a part of the water needed therein other than that supplied through condensation of the stream which is consumed. Also, if desired, a stream of the middlings recycle can be introduced onto the screen 5 to flush the pulp therethrough and into the sump. As a general rule, the total amount of water added to the natural bituminous sands as liquid water and as steam prior to the separation step should be in the range of 0.2 to 3.0 tons per ton of the bituminous sands. The amount of water needed within this range increases as the silt and clay content of the bituminous sands increases. For example, when 15 percent by weight of the mineral matter of the tar sands has a particle size below 44 microns, the fresh water added

generally can be about 0.3 to 0.5 ton per ton of tar sands. On the other hand, when 30 percent of the mineral matter is below 44 microns diameter, generally 0.7 to 1.0 ton of water should be used per ton of tar sands.

With further reference to the figure, the pulped and diluted tar sands are pumped from the sump 8 through line 11 into the separation cell 12. The cell contains a relatively quiescent body of hot water which allows for the formation of a bitumen froth which rises to the cell top and is withdrawn via line 13, and a sand tailings which settles to the bottom to be withdrawn through line 14. An aqueous middlings layer between the froth and tailings layer contains silt and clay and some bitumen which failed to form froth. In order to prevent the buildup of clay in the system it is necessary to continually remove some of the middlings layer and supply enough water in the conditioning operations to compensate for that so removed. The rate at which the middlings need to be removed from the system depends upon the content of clay and silt present in the tar sands feed and this will vary from time to time as the content of these fines varies. If the clay and silt content is allowed to build up in the system, the viscosity of the middlings layer will increase. Concurrently with such increase an increase in the proportions of both the bitumen and the sand retained by the middlings will occur. If the clay and silt content is allowed to build up too high in the system, effective separation no longer will occur and the process will become inoperative. This is avoided by regulating the recycling and withdrawal of

middlings and input of fresh water. Even when the separation step is operating properly the middlings layer withdrawn through line 15 will contain a substantial amount of bitumen which did not separate. Hence, the middlings layer withdrawn through line 15 is, for purpose of description, herein referred to as "oil-rich" or "bitumen-rich" middlings.

The bitumen-rich middlings stream withdrawn from the separator 12 through line 15 is sent to a scavenger zone 16 wherein an air flotation operation is conducted to cause the formation of additional bitumen froth. A sample of the middlings is withdrawn from the separation cell 12 and is conducted via line 17 to a sample cell 18.

In the sample cell 18 sand is allowed to settle from the sample and a settled density measurement is taken by means of the densitometer 19. The densitometer 19 controls variable speed pump 20 on line 15 so that if the settled density of the sample withdrawn from the separation cell 12 registers above the range 1.03 to 1.09, lead 21 increases the variable speed pump 20 thereby increasing the flow in line 15 to the scavenger cell 16. Increased flow to the scavenger cell 16 lowers the interface level between the middlings and froth in the separation cell 12. This change in the interface causes a decrease in the static pressure in bubble tube and rotameter 22. Pressure controller 23 senses this change and transmits a signal from recorder 24 via lead 25 to open valve 26 thus increasing the flow of fresh water addition to the sump 8 via line 9. Increased water flow

through line 9 results in increased water content in the diluted pulp passing from the sump 8 through line 11 to the separation cell 12. Flow through valve 27 is decreased via lead 28 which responds to the increase in water in the diluted pulp thereby resulting in a reduction in the amount of middlings recycle diluting the separation cell feed via 10. Thereby the proportion of fresh water in the separation cell 12 is increased, bringing about a decrease in middlings density. Correspondingly, if the settled density of the sample withdrawn via line 17 registers below the range of 1.03 to 1.09, lead 21 decreases the variable speed pump 20 thereby decreasing the flow in line 15 to the scavenger cell 16. Decreased flow to the scavenger cell raises the interface level in the separation cell 12. This causes the static pressure in the bubble tube 22 to increase. Pressure controller 23 senses this change and recorder 4 transmits a signal via lead 25 thereby closing valve 26 thus decreasing the flow of fresh water addition to the sump via line 9. Decreased water flow through line 9 results in decreased water content in the diluted pulp passing from the sump 8 through line 11 to the separation cell 12. Flow through valve 27 is increased via lead 28 which responds to the decrease in water in the diluted pulp in 11 thereby resulting in an increase in the amount of middlings recycle diluting the separation cell feed. Thus the proportion of fresh water in the separation cell 12 is decreased bringing about an increase in middlings density. The system can be operated so as to

maintain the middlings density within the preferred range of 1.05 to 1.07 instead of the broad range as described supra.

Following the process further, in the scavenger zone 16 an air flotation is conducted by any of the air flotation procedures conventionally utilized in processing of ores. This involves providing a controlled zone of aeration in the flotation cell at a locus where agitation of the middlings is being effected so that air becomes dispersed in the middlings in the form of small bubbles. The drawing illustrates a flotation cell of the sub-aeration type wherein a motorized rotary agitator is provided and air is fed thereto in controlled amounts. Alternatively the air can be sucked in through the shaft of the rotor. The rotor effects dispersion of the air in the middlings. This air causes the formation of additional bitumen froth which passes from the scavenger zone 16 through line 29 to a froth settler zone 30. A bitumen-lean middlings stream is removed and discarded from the bottom of the scavenger zone 16 via line 31.

In the settler zone 30 the scavenger froth forms into a lower layer of settler tailings which is withdrawn and recycled via line 32 to be mixed with bitumen-rich middlings for feed to the scavenger zone 16 via line 15. In the settler zone 30 an upper layer of upgraded bitumen froth forms above the tailings and is withdrawn through line 33 and mixed with primary froth from line 13 for further processing. The combined froths are at a temperature of about 160°F. They are heated with steam and diluted with sufficient naphtha or other diluent from 34 to reduce the viscosity of the bitumen for centrifuging in zone 35

to produce a bitumen product 36 suitable for further processing.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a hot water process for treating bituminous tar sands which comprises: forming a pulp of bituminous tar sands with a minor amount of water in a pulping zone; removing pulp therefrom and mixing the same with hot water and hereinafter specified recycle stream in a dilution zone; passing the mixture into a separation zone; settling the mixture in the separation zone to form an upper bitumen layer, a middlings layer comprising water, clay and bitumen, and a sand tailings layer; removing a first stream of middlings layer from the separation zone and passing it to the dilution zone as the aforsaid recycle stream, passing a second stream of middlings layer to a scavenger zone and therein recovering an additional amount of bitumen froth; and regulating the rate of passage of said second stream to the scavenger zone so as to regulate and maintain the viscosity of said middlings layer within the range of about 0.4 to 5.7 centipoises; which process further comprises:

(a) regulating the rate of passage of said second stream to the scavenger zone thereby varying the interface between said upper bitumen froth layer and said middlings layer in said separation cell;

(b) varying the amount of hot water mixed in said dilution zone in response to the variation of said interface; and

(c) varying the rate of passage of said first stream of middlings to said dilution zone in response to the variation in the amount of hot water mixed in said dilution zone;

(d) the improvement in which Step (b) comprises varying the amount of hot water mixed in said dilution zone in response to pressure variance required to inject a gas into said middlings below said interface which pressure varies in relation to the variation of the interface level.

2. The process of Claim 1 in which Steps (a), (b), (c), and the improvement (d) are conducted so as to regulate and maintain the viscosity of said middlings layer at about 1 to 2 centipoises.

3. The process of Claim 1 in which a bubble tube-differen tial pressure cell is utilized in Step (b) to vary the amount of hot water mixed in said dilution zone in response to pressure variance required to inject a gas into said middlings below said interface which pressure varies in relation to the variation of the interface level.

4. In a system for conducting a hot water process for treating tar sands comprising a conditioning drum; a separation cell; a first line for supplying tar sands pulp from said conditioning drum to said separation cell; a second line for introducing hot water into tar sands pulp in said first line; a third line for withdrawing a bitumen froth product from said cell; a fourth line for withdrawing a sand tailings layer from said cell; a fifth line for withdrawing a middlings portion from said cell; a sixth line for recycling a middlings portion from said cell to be mixed with said tar sand pulp prior to discharge into said cell; and which system further comprises:

(a) a sampling device for withdrawing a sample of middlings from said cell;

(b) a density sensing device connected to said sampling device for measuring the settled density of said sample;

(c) regulating means controllably attached to said fifth line, and responsively connected to said density sensing device to control the middlings portion withdrawn via said fifth line;

(d) regulating means operating in response to said middlings withdrawn in said fifth line and connected to said second line to control the hot water introduced to the bituminous tar sands pulp via said second line; and

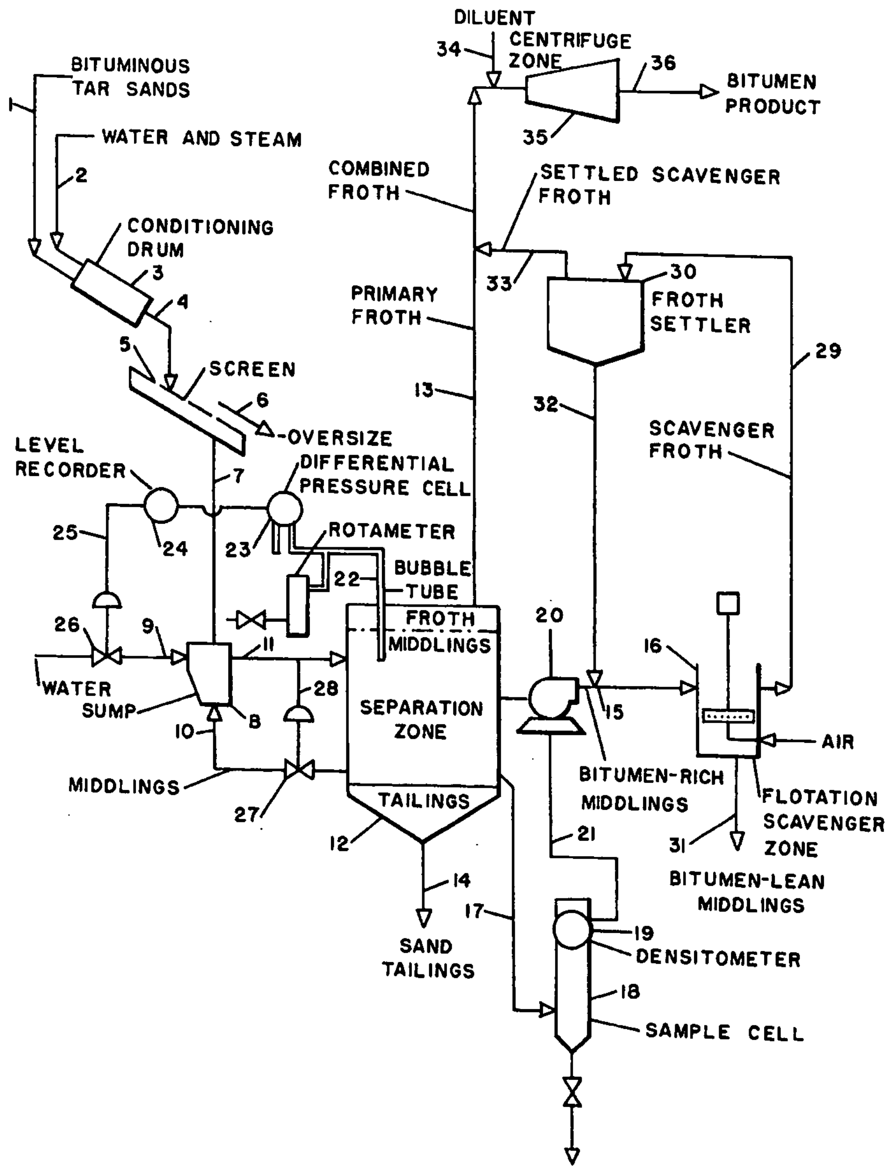
(e) regulating means operating in response to said hot water incorporated in said second line and connected to said sixth line to control the middlings portion recycled to the bituminous tar sands pulp via said sixth line;

(f) the improvement in which the regulating means of (d) operating in response to the middlings withdrawn in said fifth line comprises: a bubble tube-differential pressure cell positioned to operate in response to the middlings withdrawal in the fifth line and connected to the second line to control the hot water introduced to the bituminous tar sands pulp via said second line.

5. The system of Claim 4 in which the improvement comprises a bubble tube positioned so as to deliver gas to said middlings at a pressure which varies with the rate of middlings withdrawn in said fifth line, a differential pressure cell connected to said bubble tube cell which measures the said variance in pressure at which said gas is delivered to the middlings and a level recorder which is connected to said pressure cell which records the said pressure variance and is connected to the second line for controlling the hot water introduced to said bituminous tar sands pulp via said second line in response to said pressure variance.

6. The system of Claim 4 in which said regulating means (c) is responsively connected to said density sensing device so as to increase the viscosity of said middlings in said separation cell when said middlings viscosity is below 0.4 centipoise and so as to decrease the viscosity of said middlings in said separation cell when said middlings viscosity is above 5.7 centipoises.

7. The system of Claim 4 in which said regulating means (c) is responsively connected to said density sensing device so as to increase the viscosity of said middlings in said operation cell when said settled middlings density is below 1.03 g./ml. and so as to decrease the viscosity of said middlings in said separation cell when said settled middlings density is above 1.09 g./ml.



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